NASA SBIR 2017 Phase I Solicitation

Z9.01 Small Launch Vehicle Technologies and Demonstrations

Lead Center: MSFC

Participating Center(s): KSC, LaRC

Technology Area: TA1 Launch Propulsion Systems

As small spacecraft capabilities steadily expand the demand for low-cost dedicated launch capability is expected to grow and give rise to a viable small payload market segment. Servicing this market segment will likely require a variety of small launch vehicle capabilities to deliver payload masses ranging from 5-kg cubesats up to 180-kg ESPA-Class spacecraft. Orbital altitudes of interest range between 350 to 700 km with inclinations between 28 to 98.2 degrees to support CONUS operators and sun synchronous orbits at maximum altitude. Affordability objectives are focused on reducing launch costs below $60,000/kg with a goal of less than $20,000/kg.

NASA is interested in fostering the small spacecraft commercial launch sector by investing in new technologies and innovations that are poised for rapid maturation and subsequent commercialization. It is recognized that a combination of multiple technologies and production practices will likely be needed, and it is highly desirable that disparate but complementary technologies formulate and adopt standardized interfaces to better allow for transition and integration into small spacecraft launch systems.

Technologies of specific interest under this subtopic are as follow:

- Innovative Propulsion Technologies.
- Affordable Guidance, Navigation & Control.
- Manufacturing Innovations for Launch Vehicle Structures & Components.

Proposers are expected to quantify improvements over relevant SOA technologies and substantiate the basis for investment. Potential opportunities for technology demonstration and commercialization should be identified along with associated technology gaps. Ideally, proposed technologies would be matured to TRL 5 or 6 by the end of Phase II effort. Technologies that can be developed and readied for flight-testing by the end of Phase II effort are of particular interest. A brief descriptive summary of desired technical objectives and goals are provided below.

Innovative Propulsion Technologies

Innovative chemical propulsion technologies and system concepts are sought that can serve as the foundational basis of an affordable ground-launch or air-launch system architecture. The scope of interest includes main propulsion systems and novel reaction control systems based on solid, liquid, or hybrid propellants. Technical approaches that address the critical challenges associated with downward scaling of launch vehicles are highly sought. Solutions that directly address staging sensitivities on deliverable payload mass, for instance, would be of keen interest. Design simplicity, reliability, and reduced development and recurring costs are all important factors. Proposers should explain how their technology works and provide a quantitative assessment of State-of-Art (SOA) in terms of key performance and/or cost metrics. The degree to which the proposed technology or concept is new, different, and important should also be made evident.

Affordable Guidance, Navigation, & Control

Affordable guidance, navigation & control (GN&C) is a critical enabling capability for achieving small launch vehicle performance and cost goals. Innovative GN&C technologies and concepts are therefore sought to reduce the significant costs associated with avionics hardware, software, sensors, and actuators. The scope of interest includes embedded computing systems, sensors, actuators, algorithms, as well as modeling & design tools. Low-cost commercially available components and miniaturized devices that can be repurposed as a basis for low-SWaP GN&C systems are of particular interest. Special needs include sensors that can function during prolonged periods of high-g and high-angular rate (i.e., spin-stabilized) flight, while meeting the stringent launch system environment requirements pertaining to stability and noise. A low-cost GPS receiver capable of maintaining lock, precision, and accuracy during ascent would be broadly beneficial, for example. Sensors that can withstand these conditions might be sourced from industrial and tactical applications, and performance requirements may be achievable by fusing multiple measurements, e.g., inertial and optical (sun, horizon) sensors.

Modular actuator systems are also needed that can support de-spin and turn-over maneuvers during ascent. These can include cold-gas or yo-yo type mechanisms. Improved designs are needed to reduce the overall power and volume requirements of these types of actuator systems, while still providing enough physical force to achieve the desired maneuver and enable orbital insertion. Programmable sequencers are required to trigger actuators for events such as stage sequencing, yo-yo and shroud deployment.

In addition to hardware, software algorithms for autonomous vehicle control are needed to support in-flight guidance and steering. Robust control laws and health management software are of interest, particularly those that address performance and reliability limitations of affordable hardware. This is especially important in the typical high dynamics (acceleration and angular velocity) conditions of proposed small launch vehicles. Algorithms that are able to merge data from redundant onboard sensors could improve reliability compared to expensive single-string sensors.

Similarly, advanced ground-alignment, initialization, and state estimation routines that integrate noisy data are desired to support ascent flight. These algorithms take advantage of improved onboard computational capability in order to process observations from lower accuracy sensors to provide higher fidelity information. Implementations of state-of-the-art Unscented Kalman Filters, and Square-Root-Information Filters with robust noise and sensor models are particularly applicable.

Successful technologies should eventually be tested in relevant environments and at relevant flight conditions. Potential testbeds include a variety of spacecraft and aircraft at a variety of scales. Capabilities include reduced gravity, suborbital reusable launch vehicles, high altitude balloons, subscale to ultra-high altitude aircraft, and in-flight simulation.

Manufacturing Innovations for Launch Vehicle Structures & Components

The development of more efficient vehicle structures and components are sought to improve small launch vehicle affordability. This may include the adoption and utilization of modern lightweight materials, advanced manufacturing inspired design innovations, or systems for actively alleviating launch loads and environments. Approaches for achieving life-cycle cost reductions might also include reduced part count by substitution of multifunctional components; additive and/or combined additive and subtractive manufacturing; repurposing launch structure for post-launch mission needs; incorporating design features that reduce operating costs; adoption of lean best practices for production and manufacturing; and shifting towards commercial practices and/or componentry. Alternatively, approaches based on the utilization of heavier materials could lead to simpler parts, fewer components, and more robust design margins. Although this could yield a larger rocket and impose performance penalties, significantly reduced life-cycle costs could be realized due to overall lower manufacturing and integration cost. Proposers should provide a quantitative assessment of State-of-Art (SOA) in terms of key performance and/or cost metrics. The degree to which the proposed technology or concept is new, different, and important should also be made evident.